# AN INVESTIGATION OF RACIAL AND ETHNIC DISPARITIES IN BIRTH WEIGHT IN CHICAGO NEIGHBORHOODS*

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*We examine differences in the mean birth weights of infants born to non-Hispanic black, non-Hispanic white, and Mexican-origin Hispanic mothers (of any race) in Chicago in 1990 using linear regression models with neighborhood fixed effects. Our pooled models accounted for 64% of the black-white difference and 57% of the black/Mexican-origin Hispanic difference. Differences in the relationship between measured characteristics and birth weight accounted for around half the birth-weight gap between non-Hispanic black and other infants. Efforts to close this gap must go beyond programs that aim to reduce the level of risk factors among black women to address the causes of differences in the effects of risk factors.*

Group differences in health reflect unequal life chances. Studying these differences can reveal important etiological mechanisms in the pathway to disease and is valuable for identifying the groups who are most in need of—and most likely to benefit from—societal investments in health (Preston and Taubman 1994). For these reasons, explaining the large and persistent racial and ethnic disparities in birth outcomes and infants' health in the United States is a priority. Despite dramatic improvements in the health of all infants over the past century, significant differences persist. Today, black infants are about 2.5 times more likely to die than white infants (Minino et al. 2002). The public health impact of this disparity is enormous but underappreciated. If black newborns faced the same risk of mortality as white newborns, over 60% of the deaths of black infants—a total of about 5,000 deaths—would be averted each year.[1]

Birth weight is a key indicator of the health of infants at birth, as well as of their mothers' reproductive health. It is likely to play an important role in the production of racial and ethnic differences in infants' survival because it is one of the strongest predictors of the risk of infant mortality (Institute of Medicine 1985) and because there are major differences in birth weight across racial and ethnic groups (Martin et al. 2002).[2]

The impact of birth weight appears to extend well beyond infancy. According to the fetal-origins hypothesis (Barker 1998), fetal undernutrition, for which low birth weight is a marker, may permanently program the body—for example, by reducing the number of

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1. In 2000, there were 622,598 black births (Martin et al. 2002) and 8,771 deaths of black infants (Minino et al. 2002). The probability of white infant mortality in 2000 was 0.0056806 (Minino et al. 2002). Applying this probability to black births results in 622,598 × .0056806 = 3,537 expected deaths of infants. Thus there were 8,771 actual – 3,537 expected = 5,234 excess deaths of black infants in 2000.

2. In studying the effects of birth weight on infant mortality, it is difficult to consider the effects of birth weight independently from those of prematurity because of the strong association between low birth weight and preterm delivery (i.e., delivery before 37 weeks of gestation). In our analysis, we examined birth weight conditional on the length of gestation.

cells in specific organs, changing the distribution of types of cells, or influencing metabolic processes. These programmed changes are associated with a variety of chronic diseases during adulthood and old age, such as diabetes (Barker et al. 1993), hypertension (Law et al. 1993), and cardiovascular disease (Rich-Edwards et al. 1997). In addition, birth weight may affect physiological and developmental outcomes from infancy through childhood and into adulthood. Studies have found a significant association between birth weight and the disabilities of school-age children (Avchen, Scott, and Mason 2001), behavioral problems (Sommerfelt, Ellertsen, and Markestad 1993), school-age reading and mathematics scores (Boardman et al. 2002), cognitive function during young adulthood (Richards et al. 2001), and educational attainment in adulthood (Conley and Bennett 2000), as well as reproductive outcomes, such as low birth weight (Wang et al. 1995), preterm birth (Porter et al. 1997), and gestational diabetes (Innes et al. 2002). It is unclear, however, the extent to which birth weight has a causal effect on these outcomes (e.g., reflecting intrauterine malnutrition) or, instead, reflects the influence of unmeasured family background or genetic factors or confounding through, for instance, postnatal nutrition and stimulation.

Nevertheless, the implication of this research is that improved birth weight is likely to have a large payoff in several different domains. Most obviously, it represents an important enhancement in infant and maternal health. Second, it leads to better health and developmental outcomes during childhood and adolescence and lower levels of chronic disease during adulthood and old age. Finally, reducing disparities in birth weight by race and ethnicity will contribute to a reduction in inequalities across these groups in an array of health outcomes.

This article examines racial and ethnic disparities in birth weight in Chicago. Our analysis drew on vital statistics for all singleton births in 1990 that were registered to Chicago-resident mothers and incorporated several methodological advances that distinguish it from previous work on this topic. Of particular note is that we estimated models with tract-level fixed effects that absorbed the influence of all neighborhood-level characteristics. We were able to include such a control because the data were geocoded to identify each woman's neighborhood of residence. This is a major advantage of using data from a single city, with the cost being the potential inability to generalize the findings to other areas.

Non-Hispanic blacks in Chicago in 1990 had significantly lower average birth weights than non-Hispanic whites and Mexican-origin Hispanics. Birth outcomes were qualitatively similar for non-Hispanic whites and Mexican-origin Hispanics, which is remarkable because the latter group consisted mainly of first-generation immigrants with relatively low levels of education and other disadvantages. This "Hispanic paradox" has been widely noted in the literature (e.g., Buekens et al. 2000). The results from our regression analysis indicate that neighborhood-level factors, socioeconomic and demographic background variables, and pregnancy-related behaviors accounted for a substantial portion of the differences in birth weight across the three racial and ethnic groups. In particular, these variables explained between half and two-thirds of the difference in the average birth weights of non-Hispanic blacks and whites (and similar proportions when blacks were compared with Mexican-origin Hispanics); on the other hand, the variables accounted for *all* the difference between non-Hispanic whites and Mexican-origin Hispanics.[3] In addition, there was important variation in the effects of certain variables

3. Previous studies have explained substantially less of the disparities in birth weight or the risk of low birth weight between non-Hispanic blacks and other racial and ethnic groups (Institute of Medicine 1985). For example, Shiono et al. (1997) investigated 46 previously defined and new potential risk factors and found that, at best, they could account for less than one-third of the gap in birth weight between blacks and whites in Chicago and New York City. Berg, Wilcox, and d'Almada (2001) found that socioeconomic and behavioral factors explained approximately 10%–15% of the higher rate of very low birth weight among black mothers in Georgia. Finally, Gorman (1999), using U.S. data for 1990, reported that the unadjusted risk of low birth weight

across the three racial and ethnic groups. These differences, together with the effects of unmeasured or unmeasurable variables, accounted for the remainder of the gaps in birth weight by race and ethnicity.

## CONCEPTUAL FRAMEWORK

The conceptual framework that guided our analysis closely follows the framework used in previous studies (e.g., Cramer, 1995; Hummer 1993; Mosley and Chen 1984; Schulz et al. 2002), and hence we discuss only its novel aspects here. Our modeling approach operationalized the conceptual framework and tackled several potentially important methodological issues.

Our main extension of the conceptual framework used in previous research was to incorporate a more comprehensive specification of the effects of neighborhood factors on birth outcomes. Theory and previous research have suggested that neighborhoods affect birth weight through social, service, and physical environmental pathways (Pebley and Sastry forthcoming). These pathways originate in the structural characteristics of contemporary urban America.[4] The most influential of these structural characteristics is racial and ethnic residential segregation (Massey and Denton 1993). By promoting the spatial concentration of poverty and affluence (Massey 1996), segregation has a major impact on the social, service, and physical characteristics of neighborhoods. Closely linked to residential segregation are compositional differences across neighborhoods in a variety of dimensions, such as poverty, residential stability, family structure, age and gender distribution, average educational levels, and population density.

Almost all prior studies of the effects of neighborhoods on birth outcomes have focused exclusively on the effects of compositional factors (Collins and David 1997; O'Campo et al. 1997; Pearl, Braveman, and Abrams 2001; Rauh, Andrews, and Garfinkel 2001; Roberts 1997). However, a few studies have explored the pathways through which neighborhoods affect birth outcomes. Heck, Schoendorf, and Chavez (2002) examined the effects of proximity to prenatal services on births that were small for gestational age but found no significant effects. Buka et al. (2003) investigated the effects on birth weight in Chicago of neighborhood social support. Significant effects were found for births to white mothers but not for births to black mothers. Morenoff (2001), in another study of birth weight in Chicago neighborhoods, found violent crime to be a key predictor of lower birth weight. He also found neighborhood reciprocal exchange to be related to birth weight, but only among white and Mexican women.

A potentially large group of neighborhood- or community-level factors may affect birth weight. However, the lack of appropriate data on most of the relevant neighborhood factors and a desire to focus on the main aim of this article—namely, to examine racial and ethnic disparities in birth weight—led us to include no neighborhood-level factors in our models. Nevertheless, we believe that neighborhood factors *are* likely to be important. To reconcile these two perspectives, we included, separately for each tract, a single dummy variable. This variable captured the effects of all measured—and unmeasured—factors operating at the tract level and hence allowed us to control for the

was 2.637 times greater for non-Latino blacks than for non-Latino whites; after adjusting for a set of individual-level and county-level covariates, the odds ratio dropped to only 2.165. In contrast, a number of previous studies have fully accounted for birth-weight disparities between Hispanics and non-Hispanic whites with a standard set of covariates (e.g., Hessol and Fuentes-Afflick 2000).

4. The structural characteristics of contemporary urban America are themselves a product of current and historical economic, political, and social processes, including shifts in the industrial and employment structure of the macroeconomy; racial discrimination; migration patterns; suburbanization; and public policies regarding residential segregation, public housing, and transportation (Jargowsky 1997; Massey and Denton 1993; Sugrue 1996; Wilson 1987, 1996).

complete set of neighborhood variables, although it did not permit us to identify the specific aspects of neighborhoods that are important.[5]

## MODELING APPROACH

Our conceptual framework suggested an analytical approach to disentangling the effects of race and ethnicity on birth weight. The starting point was to examine the gross differences in mean birth weight across racial and ethnic groups. The next step was to remove the effects of neighborhood factors that, for the current analysis, we viewed principally as a nuisance. We did so by examining racial and ethnic disparities in birth weight with a model that included a control solely for tract of residence. We then began a more systematic analysis of the background and intermediate factors. We first estimated models that looked at the effects of background factors alone. The results from these models showed the gross effects of background factors while controlling for other background factors but none of the pathways or intermediate factors through which background characteristics affect birth weight. The next step was to add intermediate factors to the previous model. These results revealed how these intermediate factors affect birth weight. They also shed light on ways in which the background factors affect birth outcomes. In particular, by examining differences in the effects of background factors between this model and the previous one, we learned the extent to which the intermediate factors that we included in our models account for the gross effects.

Our first set of results shows the disparities in birth weight by racial and ethnic group—as well as the factors that account for these disparities—on the basis of models that used data that were pooled across the different groups. This approach has the advantage of providing a simple and clear way to examine the gross and net effects of race and ethnicity. In particular, the disparity in birth weight between the (omitted) baseline group and any other racial and ethnic group is represented by the coefficient on a dummy variable. This coefficient can be read directly from a table of results and is straightforward to understand and interpret. A shortcoming of the pooled data approach, however, is that it constrains the effects of all covariates to be identical for the different racial and ethnic groups. Imposing this structure on the model may be wrong and potentially misleading if the effects of covariates are substantially different across racial and ethnic groups. One solution would be to estimate models that allow for certain covariate effects to vary by race and ethnicity through the use of interaction effects. A more general approach is to stratify the data and estimate separate models for the different groups. The results from the stratified model are equivalent to those from a model that includes the full set of interaction effects involving race and ethnicity, although the former model is simpler to understand and interpret. However, it is not straightforward to summarize disparities in birth weight that remain after the included covariates were controlled using either of these models. To do so, we drew on a simple decomposition of birth-weight disparities that separates the total difference into two components, with the first component representing the contribution of differences in characteristics and the second component representing differences in the effects of any given set of characteristics. This decomposition, in essence, constructs a counterfactual case that estimates what the mean birth weight for one group (e.g., non-Hispanic whites) would be if they had their own characteristics but the relationship between these characteristics and birth weight that prevailed for another group (e.g., non-Hispanic blacks).

5. We used census tracts to represent neighborhoods. Census tracts are of a moderate size and closely approximate social definitions of neighborhoods. There is no consequence to this choice if neighborhoods are, in reality, composed of multiple tracts. However, it will matter if true neighborhoods have boundaries that bisect tracts or are smaller than tracts.

## STATISTICAL METHODS

We used linear regression models to estimate the effects on birth weight of the factors just discussed. There are several methodological issues that we addressed, and we discuss each of them in turn.

We modeled birth weight as a continuous outcome, in contrast to most—but not all—of the previous literature, which has used a dichotomous variable that distinguishes low birth weight (< 2,500 grams) from normal birth weight and logistic regression techniques.[6] We did so because a tremendous amount of information is discarded in the process of converting a continuous variable into a dichotomous one. This is a problem because it results in the loss of statistical power to estimate covariate effects with precision, which makes it more difficult to uncover true relationships that are present in the data.

Although the cutoff of 2,500 grams is meaningful in certain ways, it is arbitrary in other ways. As Rose (1992) noted, disease is nearly always a quantitative, rather than a categorical, phenomenon and hence has no natural definitions. The sharp distinction provided by the contrast of low birth weight with normal birth weight is, in many ways, a medical artifact. In particular, any increase in birth weight generally leads to lower infant mortality and better health and development outcomes, although the benefits are relatively large below 2,500 grams.[7]

We incorporated tract-level fixed effects in our models to capture the effects of all factors that influence birth weight that were common to births in the same neighborhood. These factors included measurable and unmeasurable neighborhood characteristics, as well as individual-level attributes that are shared by all mothers in the same tract. Most prior studies (e.g., Collins, Schulte, and Drolet 1998; O'Campo et al. 1997; Pearl et al. 2001; Roberts 1997) only partly adjusted for neighborhood characteristics through the incorporation of measured community-level variables. This is necessarily true because the array of community-level variables available through the decennial census or most other data sources is limited. Controlling for omitted neighborhood variables through the use of fixed effects also provides a way to account for the correlation among birth weights in the same tract that would otherwise result in the understatement of standard errors for parameter estimates. Fixed-effects models represent a specific alternative to the multilevel modeling approach that is growing in popularity among studies in public health, sociology, and other disciplines (Goldstein 1995). In particular, multilevel models are based on the incorporation of random effects (at one or more levels) that absorb level-specific errors. However, an important assumption behind standard multilevel models is that the random effects are independent of the measured covariates that appear in the model. This assumption may be commonly violated. However, few researchers test this assumption, although a straightforward statistical test, developed by Hausman (1978), is available. In contrast, fixed-effects models provide a simple means to control for the possible correlation between these unmeasured effects and the covariates that appear in the model by including a separate dummy variable for each tract represented in the data. To the extent that this correlation is present and important, it means that random-effects models, in contrast to fixed-effects models,

6. Examples of recent studies that analyzed birth weight as a dichotomous outcome include O'Campo et al. (1997), Roberts (1997), and Zhu et al. (1999). Among the studies that examined birth weight as a continuous outcome are Collins and David (1997), Pearl et al. (2001), and Shiono et al. (1997).

7. Wilcox (2001) argued that birth weight does not have a causal effect on infant mortality. He suggested that birth weight is the most useful for identifying small preterm births, which he contended is the only component of birth weight that directly affects infant mortality. Wilcox's point was that a unit increase in birth weight may not have the same effects on the risks of infant mortality across racial and ethnic groups, given their different birth-weight distributions. However, it is not clear whether this argument extends to other important outcomes that are also of interest, such as measures of development and other health outcomes—particularly those in later childhood and in adulthood. Given this uncertainty, we decided not to analyze birth weight normalized by ethnic group, the approach Wilcox suggested.

lead to biased and inconsistent parameter estimates.[8] The fixed-effects approach was a better choice for our analysis because a series of formal Hausman tests comparing this approach to the random-effects approach consistently rejected the assumption on which the random-effects model is based (namely, that the regressors and the random tract-level effect are uncorrelated). The main disadvantage of a fixed-effects approach is that it precluded our ability to include neighborhood-level variables in the models. Examining the effects of specific neighborhood-level factors, however, was not our goal.

An additional complication in studies such as ours that analyze data from contiguous neighborhoods is the potential for spatial correlation. Similarities, or interactions, between neighboring areas could lead to spatial correlation in the error terms. Standard errors that do not take this correlation into account may be understated, leading possibly to incorrect statistical inference. However, the fixed effects capture not only tract-specific factors but also time-invariant correlation among tracts. Thus, the fixed-effects approach reduces the problem of spatial correlation. Finally, we report heteroscedasticity-consistent standard errors (estimated via the Huber-White sandwich procedure) that should also diminish the effects of any remaining spatial correlation.

## DATA AND SETTING

The data for our study were based on individual birth-certificate records for all births in 1990 that occurred to mothers who resided in the city of Chicago.[9] The size and diversity of Chicago and the large disparities in health found there made this city an interesting and important setting for our research.

There were 60,242 live births to Chicago-resident mothers in 1990. For our analysis, we used information on 49,104 singleton births with complete information that were born to mothers who were non-Hispanic white (12,918 births), non-Hispanic black (26,005), or Mexican-origin Hispanic (10,181). We excluded all 1,530 multiple births (2.5% of the total) because they differ systematically from singleton births, and the approximately 3,235 births (5.4% of the total) for which key variables (such as birth weight or mother's race and ethnicity) were missing. We also excluded 6,373 births to mothers of other racial and ethnic groups. The majority of these births (4,440) were to non-Mexican Hispanics, principally mothers from Puerto Rico (2,808) and Central and South America (881). We focused on the three largest racial and ethnic groups because the sizes of the remaining groups were substantially smaller and preliminary findings suggested that the different groups could not be pooled.

A key feature of these data is that the residential address of the mother was geocoded—that is, the latitude-and-longitude coordinates specifying the exact location of the residence were calculated and assigned to each record. The geocoded address was used to determine the census tract of residence.[10] Approximately 99% of the addresses were successfully geocoded with a valid census-tract identifier.

The 1989 revision of the *U.S. Standard Certificate of Live Birth* includes a considerable amount of information on the pregnancy, birth, and demographic characteristics of the mother (see National Center for Health Statistics 1999). However, no information on the economic status of the mother or her household is available. Birth-certificate data are

8. Random-effects models provide more efficient estimates and hence are preferred when correlation between the unobserved effects and measured covariates is unimportant.

9. Birth-weight distributions in the United States have remained stable over the past 30 years (Gortmaker and Wise 1997), lending some relevance to these data beyond their historical interest.

10. The data were geocoded by the Chicago Department of Public Health. The Illinois Department of Public Health also created a database with geocoded birth records. However, we relied on the Chicago Department of Public Health database because its geocoding was more accurate. In particular, geocoding errors affecting as much as 10% of all Chicago birth records for the period 1989–1996 were discovered in the birth-record files of the Illinois Department of Public Health.

**Table 1. Summary Birth-Weight Statistics, by Racial/Ethnic Group, Chicago, 1990**

| Measure | Non-Hispanic Whites | Non-Hispanic Blacks | Mexican-Origin Hispanics | Total |
|---|---|---|---|---|
| Birth Weight (grams) | | | | |
| Mean | 3,418.5 | 3,086.8 | 3,383.7 | 3,235.7 |
| Standard deviation | 568.7 | 628.9 | 546.4 | 617.7 |
| Low Birth Weight (< 2,500 grams) (%) | 4.8 | 13.4 | 4.4 | 9.1 |
| Very Low Birth Weight (< 1,500 grams) (%) | 0.9 | 2.7 | 0.8 | 1.7 |
| Number of Observations | 12,918 | 26,005 | 10,181 | 49,104 |

*Source:* Authors' calculations using 1990 data on Chicago vital statistics.

largely retrospective and hence may be misreported. Although misreporting is unlikely for certain characteristics, such as education, it is more likely for the use of alcohol, tobacco, and illicit substances. Validation studies have suggested that birth weight is recorded reliably on birth certificates (Buescher et al. 1993; Piper et al. 1993). Information on maternal medical risk factors, complications of labor and delivery, and conditions of the newborn appears to be somewhat less reliable (Adams 2001; Buescher et al. 1993; Piper et al. 1993). Although data on tobacco use during pregnancy appear to be more reliable than data on alcohol use, there is evidence that both behaviors are underreported on birth certificates (Buescher et al. 1993; Piper et al. 1993).

## Birth Weight

The mean birth weight across the three racial and ethnic groups was 3,236 grams (see Table 1). Non-Hispanic whites had a mean birth weight of 3,419 grams, while non-Hispanic blacks averaged 3,087 grams and Mexican-origin Hispanics' mean birth weight was 3,384 grams.

Although differences in average birth weights across the three groups were relatively modest, they translated into substantial differences in the rates of low birth weight. For example, 13.4% of the births to non-Hispanic blacks were of low birth weight (< 2,500 grams), which was almost three times higher than the rate among non-Hispanic whites of 4.8%.

## Model Covariates and Their Differences Across Racial and Ethnic Groups

The covariates of birth weight that we examined were suggested by the conceptual framework and circumscribed by information contained in the vital statistics for births. Although the specific covariates were similar to those used in previous studies, a number were coded differently, and we highlight these differences in the brief overview of the model covariates that we provide here. We also discuss similarities and differences in summary statistics for covariates across the three racial and ethnic groups.

The list of covariates we examined appears in Table 2, along with the means for the three racial and ethnic groups and the sample as a whole. Background characteristics for the child and the mother included the child's sex and the mother's age, marital status, nativity, education, and race. For mother's education, Table 2 shows summary statistics for the number of years of schooling. In our models, however, we examined the effects of years of schooling beyond the 11th grade. Our preliminary models suggested that it was reasonable to pool all mothers who had not completed high school as a single, homogeneous group and then to consider the linear effects of an additional year of education. This technique provided a good compromise between simplicity and obtaining a good fit to the

**Table 2. Means (and Standard Deviations) or Percentage, by Category, for Independent Variables, by Racial/Ethnic Group, Chicago, 1990**

| Variable | Non-Hispanic Whites | | Non-Hispanic Blacks | | Mexican-Origin Hispanics | | Total | |
|---|---|---|---|---|---|---|---|---|
| Infant's Sex (%) | | | | | | | | |
| Male | 51.1 | | 50.5 | | 51.6 | | 50.9 | |
| Female | 48.9 | | 49.5 | | 48.4 | | 49.1 | |
| Mother's Education (years) | 13.3 | (2.6) | 12.0 | (1.7) | 8.9 | (3.4) | 11.7 | (2.8) |
| Mother's Nativity (%) | | | | | | | | |
| U.S. born | 81.8 | | 98.2 | | 18.8 | | 77.4 | |
| Foreign born | 18.2 | | 1.8 | | 81.2 | | 22.6 | |
| Mother's Marital Status (%) | | | | | | | | |
| Not married | 19.8 | | 82.0 | | 33.8 | | 55.6 | |
| Married | 80.2 | | 18.0 | | 66.3 | | 44.4 | |
| Mother's Age (years) | 28.3 | (5.7) | 23.9 | (5.9) | 25.5 | (5.7) | 25.4 | (6.1) |
| First Birth (%) | | | | | | | | |
| No | 53.4 | | 64.6 | | 64.2 | | 61.6 | |
| Yes | 46.6 | | 35.4 | | 35.8 | | 38.4 | |
| Interpregnancy Interval[a] (months) | 34.9 | (33.7) | 37.7 | (39.3) | 37.6 | (32.7) | 37.0 | (36.7) |
| Interpregnancy Interval Missing[a] (%) | | | | | | | | |
| No | 98.1 | | 97.8 | | 97.2 | | 97.8 | |
| Yes | 1.9 | | 2.2 | | 2.8 | | 2.2 | |
| Gestation Length (weeks) | 39.2 | (2.1) | 38.5 | (2.8) | 39.2 | (2.1) | 38.8 | (2.5) |
| Adequacy of Prenatal-Care Initiation (%) | | | | | | | | |
| Inadequate | 4.4 | | 10.5 | | 7.7 | | 8.3 | |
| Intermediate | 6.4 | | 14.2 | | 13.2 | | 12.0 | |
| Adequate | 22.3 | | 34.9 | | 32.3 | | 31.0 | |
| Adequate plus | 66.9 | | 40.5 | | 46.8 | | 48.8 | |
| Adequacy of Prenatal-Care Visits (%) | | | | | | | | |
| Inadequate | 5.7 | | 14.0 | | 8.7 | | 10.7 | |
| Intermediate | 19.9 | | 28.9 | | 28.0 | | 26.4 | |
| Adequate | 51.7 | | 31.3 | | 42.6 | | 39.0 | |
| Adequate plus | 22.8 | | 25.9 | | 20.7 | | 24.0 | |
| Number of Prenatal-Care Visits | 11.1 | (4.5) | 9.2 | (5.0) | 9.7 | (4.7) | 9.8 | (5.4) |

*(continued)*

data. In particular, it was much better than treating education as linear through its entire range or having a dummy variable that compared high school graduates with non-high school graduates. The other background variables followed standard coding practices.

There were large differences between the racial and ethnic groups in mother's education, nativity, marital status, and age. Mexican-origin Hispanics had substantially lower levels of education and were vastly more likely to have been foreign born than were the

*(Table 2, continued)*

| Variable | Non-Hispanic Whites | | Non-Hispanic Blacks | | Mexican-Origin Hispanics | | Total | |
|---|---|---|---|---|---|---|---|---|
| Prenatal-Care Initiation Missing (%) | | | | | | | | |
| No | 98.4 | | 98.2 | | 98.1 | | 98.3 | |
| Yes | 1.6 | | 1.8 | | 1.9 | | 1.7 | |
| Prenatal-Care Visits Missing (%) | | | | | | | | |
| No | 98.8 | | 99.0 | | 98.6 | | 98.9 | |
| Yes | 1.2 | | 1.0 | | 1.4 | | 1.1 | |
| Medical-Risk Factors (%) | | | | | | | | |
| None | 80.5 | | 83.0 | | 87.6 | | 83.3 | |
| Any | 19.5 | | 17.0 | | 12.4 | | 16.7 | |
| Smoked During Pregnancy (%) | | | | | | | | |
| No | 82.6 | | 80.4 | | 97.3 | | 84.5 | |
| Yes | 17.4 | | 19.6 | | 2.7 | | 15.5 | |
| Cigarettes per Day[b] | 16.2 | (11.2) | 13.9 | (12.5) | 13.2 | (13.6) | 14.5 | (12.2) |
| Alcohol Use During Pregnancy (%) | | | | | | | | |
| Some | 3.3 | | 3.5 | | 0.5 | | 2.8 | |
| None | 96.7 | | 96.5 | | 99.5 | | 97.2 | |
| Alcoholic Drinks per Week[c] | 1.0 | (2.2) | 2.4 | (4.5) | 1.0 | (1.7) | 1.9 | (3.9) |
| Alcohol Use Missing (%) | | | | | | | | |
| No | 98.1 | | 98.5 | | 99.7 | | 98.6 | |
| Yes | 1.9 | | 1.5 | | 0.3 | | 1.4 | |
| Place of Delivery (%) | | | | | | | | |
| Hospital | 99.0 | | 98.9 | | 99.8 | | 99.1 | |
| Other | 1.0 | | 1.1 | | 0.2 | | 0.9 | |
| Birth Attendant (%) | | | | | | | | |
| Medical person | 94.2 | | 92.6 | | 91.7 | | 92.8 | |
| Midwife | 2.8 | | 1.3 | | 2.3 | | 1.9 | |
| Other | 3.1 | | 6.1 | | 6.0 | | 5.3 | |
| Number of Observations | 12,918 | | 26,005 | | 10,181 | | 49,104 | |

*Source*: Authors' calculations using 1990 data on Chicago vital statistics.

*Note:* Numbers in parentheses are standard deviations.

[a]Among women with a prior live birth.

[b]Cigarettes per day among women who smoked during pregnancy.

[c]Alcoholic drinks per week among women who used alcohol during pregnancy.

other groups. The mean years of education for Mexican-origin Hispanic mothers was 8.9 years, 3 years less than for non-Hispanic blacks and almost 4.5 years less than for non-Hispanic whites. Over 80% of the Mexican-origin Hispanics were foreign born, in contrast to 18% of the non-Hispanic whites and fewer than 2% of the non-Hispanic blacks. The non-Hispanic blacks stand out in terms of the percentage of births to unmarried mothers, which at 82% were 2.5 times higher than for Mexican-origin Hispanics and over 4 times higher than for non-Hispanic whites. The non-Hispanic black women had births at much younger ages than did the women in the other two groups.

Intermediate covariates included first-birth status, interpregnancy interval, gestation length, adequacy of prenatal care, medical risk factors, tobacco and alcohol use, place of delivery, and birth attendant. The interpregnancy interval was modeled as a three-part linear spline[11] that provided an excellent fit to the data—substantially better than treating this covariate as a categorical variable (as Rawlings, Rawlings, and Read 1995 or Zhu et al. 1999 did). Our coding of this variable was based on a preliminary analysis that showed birth weight to have a strong positive relationship with interpregnancy intervals when there were fewer than 12 months separating the births, a moderate positive relationship for interpregnancy intervals between 12 and 59 months, and a weak negative relationship after 60 months. First births were set to the mean and were flagged using a separate covariate. Gestation length was also modeled as a spline, with a break at 41 weeks that reflects an increase in birth weight with the length of gestation up to this point (which marks the end of the normal duration of gestation) and a decline beyond it. Information from the birth certificate on the number of prenatal care visits and the month during the pregnancy that prenatal care began were recoded into Kotelchuck's (1994a, 1994b) Adequacy of Prenatal Care Utilization Index that includes two parts. The first part provides an assessment of the timing of the initiation of prenatal care, and the second part describes the frequency of prenatal-care visits after initiation. In addition, we examined the effects of the number of prenatal-care visits, which were also modeled as a two-part spline with a knot at the mean of 14 visits.[12] Information on 16 different medical-risk factors during pregnancy was collected on birth certificates beginning in 1989. In our models, we included a covariate indicating whether a woman had any medical-risk factors because the quality of the information on any specific item is subject to reporting error.

The non-Hispanic whites generally had the most favorable set of intermediate factors related to pregnancy and delivery. They had the lowest fertility rates, although they subsequently had shorter interpregnancy intervals. Almost half the births to non-Hispanic whites were first births, in contrast to about one-third of births for the other two groups. The non-Hispanic whites were far more likely to have had adequate or better prenatal care, according to both the timing of the initiation of care and the number of prenatal care visits. Approximately 90% of the non-Hispanic whites had adequate or better prenatal-care initiation, compared with three-quarters of the non-Hispanic blacks and Mexican-origin Hispanics. The non-Hispanic whites reported a higher number of medical-risk factors than did the other two groups, although this higher number may be related to the better prenatal care that they received.

The Mexican-origin Hispanics had a number of highly favorable intermediate factors. Most notably, they had low reported rates of smoking and alcohol use during pregnancy. Less than 3% of the Mexican-origin Hispanic mothers reported smoking during pregnancy, compared with 17% of the non-Hispanic white mothers and almost 20% of the non-Hispanic black mothers. Half of 1% of the Mexican-origin Hispanic mothers reported consuming any alcohol during pregnancy; rates for the non-Hispanic black mothers and white mothers were roughly seven times higher, although the non-Hispanic black mothers who drank reported an average of 2.4 alcoholic drinks per week compared with 1 drink per week by non-Hispanic white mothers who drank. Smoking and alcohol use during pregnancy were self-reported by the mothers and hence may be subject to reporting

11. A spline is a piecewise function that is composed of connecting linear segments. It provides a simple and straightforward approach to modeling nonlinear relationships.

12. Previous research found a negative linear relationship between the number of prenatal-care visits and the likelihood of preterm delivery up to 14 visits, with an increase beyond this point (Vintzileos et al. 2002). After 14 visits, an additional visit increasingly indicates a high-risk pregnancy that required greater medical attention.

biases. The Mexican-origin Hispanic mothers were less likely to have a medical-risk factor (only 12% did) than were the non-Hispanic black mothers (17%) or the non-Hispanic white mothers (20%).

Similar across the three racial and ethnic groups were place of delivery and birth attendant. The adequacy of prenatal-care initiation was similar for the non-Hispanic blacks and the Mexican-origin Hispanics, although the latter group had more prenatal care visits. These two groups also had similar reproductive patterns, as reflected in the proportion of first births. Finally, the non-Hispanic whites and the Mexican-origin Hispanics had similar mean gestation length (of 39.2 weeks), while the non-Hispanic blacks had a shorter mean length (38.5 weeks).

## RESULTS

Our results are presented in three subsections. In the first subsection, we present the results for models that were estimated using data pooled across the three racial and ethnic groups. We then present models that were estimated separately for each group. Finally, we present a decomposition of racial and ethnic differences in birth weight.

All our results are based on the linear regression models described earlier. The parameter estimates show the effect on birth weight in grams of a one-unit increase in the explanatory variable for a continuous covariate or a one-category change, compared with the baseline group, for a categorical covariate. The tables of results include, for each parameter estimate, its standard error in parentheses and indicate the level of statistical significance.

### Results From Models Estimated Using Pooled Data

We present our first set of findings in Table 3, which shows the results for four different models of birth weight estimated using data that were pooled across all three racial and ethnic groups. We begin by focusing on racial and ethnic differences in birth weight across the four models. In Model 1, which includes only a control for race and ethnicity, we recover the means from Table 1 and highlight the differences in birth weight between the baseline group (non-Hispanic blacks) and the other two groups (non-Hispanic whites and Mexican-origin Hispanics). The parameters in this model can be interpreted as the average difference in birth weight between non-Hispanic blacks and, say, non-Hispanic whites if we picked one non-Hispanic black birth and one non-Hispanic white birth from anywhere in Chicago. On average, we would find that non-Hispanic whites had birth weights that were 332 grams higher than those of non-Hispanic blacks. Birth weights for Mexican-origin Hispanics were only slightly lower than the average for non-Hispanic whites, but were substantially above those for non-Hispanic blacks.

The introduction of fixed effects for each census tract in Model 2 changes the nature of the comparison of birth weights across racial and ethnic groups. In particular, by controlling for all measurable and unmeasurable neighborhood-level variables through the use of a tract-specific dummy variable, we essentially examined birth-weight disparities by racial and ethnic group among births that occurred in the same neighborhood. We found that neighborhood factors accounted for 30% of the average birth-weight disparity between non-Hispanic whites and non-Hispanic blacks; the difference in birth weight between these two groups is 231 grams in Model 2, down from 332 grams in Model 1. The birth-weight disparity between non-Hispanic blacks and Mexican-origin Hispanics dropped 14%, from 297 grams to 255 grams. Fixed effects provide a nearly perfect control for neighborhood characteristics, although they provide no insights into what specific neighborhood factors may be important. In addition, neighborhood effects in the model will pick up any observed or unobserved individual characteristics that were shared by all births in the same tract. Nevertheless, these results suggest that neighborhood factors played a significant role in explaining racial and ethnic differences in birth weight.

**Table 3. Linear Regression Models of Birth Weight for All Births in Chicago, 1990**

| Variable | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Infant's Sex | | | | | | | | |
| Male[a] | — | — | — | — | — | — | — | — |
| Female | — | — | — | — | –113.6*** | (5.4) | –116.9*** | (4.1) |
| Mother's Race | | | | | | | | |
| Non-Hispanic white | 331.7*** | (6.4) | 230.6*** | (13.0) | 174.9*** | (13.2) | 119.4*** | (10.2) |
| Non-Hispanic black[a] | — | — | — | — | — | — | — | — |
| Mexican-origin Hispanic | 296.9*** | (7.0) | 255.2*** | (12.9) | 214.5*** | (14.7) | 126.2*** | (11.4) |
| Mother's Education[b] (years) | — | — | — | — | 19.7*** | (2.0) | 8.4*** | (1.6) |
| Mother's Nativity | | | | | | | | |
| U.S. born[a] | — | — | — | — | — | — | — | — |
| Foreign born | — | — | — | — | 3.3 | (10.0) | –17.9* | (7.7) |
| Mother's Marital Status | | | | | | | | |
| Not married[a] | — | — | — | — | — | — | — | — |
| Married | — | — | — | — | 120.8*** | (7.3) | 45.4*** | (5.7) |
| Mother's Age (years) | — | — | — | — | –1.5** | (0.5) | 1.2* | (0.5) |
| First Birth | | | | | | | | |
| No[a] | — | — | — | — | — | — | — | — |
| Yes | — | — | — | — | — | — | –100.0*** | (5.3) |
| Interpregnancy Interval[c] (spline) | | | | | | | | |
| 0–11 months | — | — | — | — | — | — | 7.7*** | (1.2) |
| 12–59 months | — | — | — | — | — | — | 0.2 | (0.2) |
| 60 or more months | — | — | — | — | — | — | –0.9*** | (0.1) |
| Interpregnancy Interval Missing[c] | | | | | | | | |
| No[a] | — | — | — | — | — | — | — | — |
| Yes | — | — | — | — | — | — | –43.2** | (14.3) |
| Gestation Length (spline) | | | | | | | | |
| 18–41 weeks | — | — | — | — | — | — | 149.5*** | (1.1) |
| 42–50 weeks | — | — | — | — | — | — | –21.2** | (7.1) |
| Adequacy of Prenatal-Care Initiation | | | | | | | | |
| Inadequate | — | — | — | — | — | — | 19.1† | (11.5) |
| Intermediate | — | — | — | — | — | — | 18.7* | (8.7) |
| Adequate | — | — | — | — | — | — | –7.1 | (5.3) |
| Adequate plus[a] | — | — | — | — | — | — | — | — |
| Adequacy of Prenatal-Care Visits | | | | | | | | |
| Inadequate | — | — | — | — | — | — | –39.4*** | (11.8) |
| Intermediate | — | — | — | — | — | — | –22.2** | (6.9) |
| Adequate[a] | — | — | — | — | — | — | — | — |
| Adequate plus | — | — | — | — | — | — | –2.0 | (6.9) |
| Number of Prenatal-Care Visits (spline) | | | | | | | | |
| 0–14 visits | — | — | — | — | — | — | 5.6*** | (1.4) |
| 15 or more visits | — | — | — | — | — | — | 1.2 | (1.3) |

*(continued)*

*(Table 3, continued)*

| Variable | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Prenatal-Care Initiation Missing | | | | | | | | |
| No[a] | — | — | — | — | — | — | — | — |
| Yes | — | — | — | — | — | — | 75.0** | (24.3) |
| Prenatal-Care Visits Missing | | | | | | | | |
| No[a] | — | — | — | — | — | — | — | — |
| Yes | — | — | — | — | — | — | –53.7† | (29.7) |
| Medical-Risk Factors | | | | | | | | |
| None[a] | — | — | — | — | — | — | — | — |
| Any | — | — | — | — | — | — | –19.7*** | (5.7) |
| Smoked During Pregnancy | | | | | | | | |
| No[a] | — | — | — | — | — | — | — | — |
| Yes | — | — | — | — | — | — | –162.5*** | (9.1) |
| Cigarettes per Day[d] | — | — | — | — | — | — | –0.7 | (0.4) |
| Alcohol Use During Pregnancy | | | | | | | | |
| None[a] | — | — | — | — | — | — | — | — |
| Some | — | — | — | — | — | — | –94.1*** | (22.4) |
| Alcoholic Drinks per Week[e] | — | — | — | — | — | — | 2.7 | (3.6) |
| Alcohol Use Missing | | | | | | | | |
| No[a] | — | — | — | — | — | — | — | — |
| Yes | — | — | — | — | — | — | 57.7* | (28.3) |
| Place of Delivery | | | | | | | | |
| Hospital[a] | — | — | — | — | — | — | — | — |
| Other | — | — | — | — | — | — | –60.5** | (22.5) |
| Birth Attendant | | | | | | | | |
| Medical person[a] | — | — | — | — | — | — | — | — |
| Midwife | — | — | — | — | — | — | 37.2* | (15.3) |
| Other | — | — | — | — | — | — | –14.0 | (9.4) |
| Constant | 3,086.8*** | (3.7) | 3,122.1*** | (6.2) | 3,119.1*** | (7.4) | 3,530.7*** | (36.3) |
| Model *F* test (*df*) | 1,727.3*** | (2) | 214.9*** | (2) | 194.6*** | (7) | 1,077.2*** | (33) |
| Tract Fixed Effects | No | | Yes | | Yes | | Yes | |
| Tract Fixed Effects *F* test (*df*) | — | — | 1.41*** | (806) | 1.19*** | (806) | 1.18*** | (806) |
| Adjusted $R^2$ | 0.07 | | 0.06 | | 0.09 | | 0.46 | |
| Number of Observations | 49,104 | | 49,104 | | 49,104 | | 49,104 | |

*Source*: Authors' calculations using 1990 data on Chicago vital statistics.

*Note:* Standard errors are shown in parentheses.

[a]Reference category.

[b]Years of schooling beyond the 11th grade.

[c]Among women with a prior live birth.

[d]Cigarettes per day among women who smoked during pregnancy.

[e]Alcoholic drinks per week among women who used alcohol during pregnancy.

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

Models 3 and 4 introduce additional controls for background and intermediate characteristics. We interpret the coefficients for race and ethnicity in these models to be the average difference in birth weight among births in the same neighborhood after controlling for differences in mother's education, nativity, marital status, age, and child sex (Model 3), as well as birth order, interpregnancy intervals, gestation length, prenatal care, medical-risk factors, smoking and alcohol use, place of delivery, and delivery assistance (Model 4).

In Model 3, background factors accounted for 17% of the total differences in mean birth weight between non-Hispanic blacks and non-Hispanic whites, and adding intermediate factors accounted for a further 17% of the difference. For the comparison between Mexican-origin Hispanics and non-Hispanic blacks, background factors explained 14% of the difference, and intermediate factors explained an additional 30%. Model 4, which includes the full set of covariates, explained 64% of the mean birth-weight difference between non-Hispanic blacks and non-Hispanic whites and 57% of the difference between Mexican-origin Hispanics and non-Hispanic blacks. Note, however, that the remaining unexplained difference in birth weight is statistically significant at the .01 level for both comparisons (although the difference between non-Hispanic whites and Mexican-origin Hispanics is not statistically significant). Our results indicate that observed differences in a comprehensive set of covariates describing the mother's demographic and social characteristics, as well as the mother's behaviors before and during her pregnancy, accounted for a considerable part of the differences across racial and ethnic groups. Still, roughly 36%–43% of the difference between non-Hispanic blacks and the two comparison groups remains unexplained by the variables in our model.

Two sets of factors account for the unexplained portion of the difference. First, several potentially important covariates were not included in the model because they were either not measured or had a large fraction of missing values. These covariates included measures of the economic status of the mother and the household to which she belonged, background characteristics of the father, and indicators describing the healthiness of the mother (such as her height and her own birth weight). Although indicators of economic status and the mother's healthiness can be measured in principle, they are not collected on birth certificates. Information on fathers is collected on birth certificates, but missing data was a major problem. There are, in addition, unmeasurable child and mother factors that we were unable to control for. Second, our models assume that the effects of all covariates on birth weight operate exactly the same way for each racial and ethnic group. There are, however, good reasons to expect differences in covariate effects, at least for certain types of variables. For instance, there were substantial differences in marriage patterns across racial and ethnic groups, reflecting, in part, the distinct types of marriage markets, competing prospects, and cultural constraints or opportunities that each group faced. These differences may also mean that being married was associated with different support arrangements across the groups, which, in turn, could translate into marital status having different effects on birth weight.[13] This issue is important not only from a modeling point of view but also with regard to the policy implications of the findings. In particular, the pooled model implies that, from a policy perspective, efforts to reduce the birth-weight gap among racial and ethnic groups should focus on improving the *characteristics* of disadvantaged groups. However, allowing different covariate effects across the groups will tell us the extent to which *relationships* may be different, which may

13. To make this illustration more concrete, consider that non-Hispanic blacks may have lower birth weights than non-Hispanic whites not only because they have lower marriage rates (and knowing that, after controlling for other factors, children born to married parents have higher birth weights), but perhaps because the beneficial effects of having a birth within a marriage are smaller for non-Hispanic blacks. The benefits of having a birth within a marriage may be smaller for non-Hispanic blacks, for example, because lower marriage rates mean that marriage is a weaker institution, and hence fewer resources, less care, and limited information are provided to the mother by her husband.

suggest an alternative set of interventions. We investigate this issue in more detail in the next subsection. In the remainder of this subsection, we describe the results for the other covariates in our models.

There were positive effects on birth weight of the infant's sex, mother's education, and mother's marital status. Each year of education beyond the 11th grade was associated with a 20-gram increase in birth weight. Especially large effects were present for infant's sex and mother's marital status. Girls had birth weights that were 114 grams lower than boys', and children who were born to married mothers had birth weights that were 121 grams higher, on average, than those of children who were born to unmarried mothers. Mother's nativity was not associated with birth weight in Model 3, but it was negative and significant in Model 4. The effect of mother's age was negative and significant in Model 3 but positive and significant in Model 4.

The background variables included in the models presented in Table 3 represent a range, from purely biological (infant's sex) to largely social (marital status). A comparison of the estimated effects of these background variables between Models 3 and 4 shows that a substantial portion of the largely social variables is accounted for by the intermediate variables. For instance, births to married women were 121 grams heavier than those to unmarried women when other background characteristics but no intermediate variables were controlled (Model 3). Adding the intermediate variables (in Model 4) lowered the beneficial effect of being married by almost two-thirds. In contrast, there was no difference in the effect of infant's sex between Models 3 and 4 because this variable does not operate through a behavioral pathway.

Among the intermediate variables, we found that first births have birth weights that are 100 grams lower than births of higher parity. Birth weights increased with interpregnancy intervals, with the effect especially strong for the first 11 months, then declining, and finally switching to a small negative effect after 60 months. It is not surprising that gestation length had an exceptionally large effect. Our results indicate that one additional week of gestation was associated with a 150-gram increase in birth weight; only when gestation length exceeded 42 weeks did a negative effect appear. There were relatively small effects associated with the number of prenatal-care visits, while the timing of initiation was not statistically significant. Nevertheless, there was a clear positive association between a greater number of prenatal-care visits and higher birth weight. The presence of one or more medical-risk factors during the pregnancy was associated with a modest decline in birth weight. Finally, smoking and alcohol use during pregnancy were associated with large deleterious effects on birth weight that were highly significant. Smoking during pregnancy lowered the birth weight by 163 grams, while alcohol use was associated with a 94-gram drop.

### Results From Models Stratified by Race and Ethnicity

Because there may be important differences in covariate effects across racial and ethnic groups, we stratified the sample and reestimated the final two models from Table 3 separately for non-Hispanic whites, non-Hispanic blacks, and Mexican-origin Hispanics. The results for the models that included only background variables are presented in Table 4, and the results for the models that added intermediate variables are presented in Table 5. We focus our discussion on covariates whose effects differed substantially across racial and ethnic groups. We do so because the stratified models (or models that interact these covariates with the race and ethnicity variables) provide unique substantive and policy insights only for these variables. Covariate effects that differed substantially by race and ethnicity included mother's age, education, and nativity; medical-risk factors; and alcohol use.

There were relatively small differences by race and ethnicity in covariate effects for the remaining variables, including infant's sex, mother's marital status, first births,

**Table 4. Fixed-Effects Linear Regression Models of Birth Weight, by Racial/Ethnic Group, Chicago, 1990: Background Variables**

| Variable | Non-Hispanic Whites | | Non-Hispanic Blacks | | Mexican-Origin Hispanics | |
|---|---|---|---|---|---|---|
| Infant's Sex | | | | | | |
| Male[a] | — | — | — | — | — | — |
| Female | –119.3*** | (10.0) | –114.9*** | (7.8) | –102.8*** | (10.9) |
| Mother's Education[b] (years) | 15.6*** | (3.0) | 33.7*** | (3.3) | –1.3 | (5.2) |
| Mother's Nativity | | | | | | |
| U.S. born[a] | — | — | — | — | — | — |
| Foreign born | –35.6* | 14.0 | 89.6** | 31.4 | –5.8 | 15.4 |
| Mother's Marital Status | | | | | | |
| Not married[a] | — | — | — | — | — | — |
| Married | 155.0*** | 14.9 | 131.5*** | 11.4 | 76.3*** | 12.2 |
| Mother's Age (years) | –0.8 | 1.0 | -6.6*** | 0.8 | 9.5*** | 1.0 |
| Constant | 3,322.2*** | 13.9 | 3,070.0*** | 7.1 | 3,383.4*** | 15.9 |
| Model $F$ test ($df$) | 66.2*** | (5) | 106.9*** | (5) | 50.6*** | (5) |
| Tract Fixed Effects | Yes | | Yes | | Yes | |
| Tract Fixed Effects $F$ test ($df$) | 1.15** | (602) | 1.18** | (628) | 1.17** | (492) |
| Adjusted $R^2$ | 0.03 | | 0.02 | | 0.02 | |
| Number of Observations | 12,918 | | 26,005 | | 10,181 | |

*Source:* Authors' calculations using 1990 data on Chicago vital statistics.

*Note:* Standard errors are shown in parentheses.

[a]Reference category.

[b]Years of schooling beyond the 11th grade.

*$p$ < .05; **$p$ < .01; ***$p$ < .001

gestation length, and cigarette smoking. Consequently, the simpler models presented in Table 3 that used data that were pooled across all racial and ethnic groups would be fine for these variables, even when there were dramatic differences in characteristics across racial and ethnic groups. One example concerns the effects of mother's marital status. Results from the pooled model (Model 3, Table 3) show that children who were born to married women had birth weights that were 121 grams higher than those of their nonmarried counterparts. When we estimated this relationship separately by race and ethnicity, we found (from Table 4) that the marriage effect was 155 grams for non-Hispanic whites, 132 grams for non-Hispanic blacks, and 76 grams for Mexican-origin Hispanics. Especially noteworthy is the relative similarity in the effects for non-Hispanic whites and blacks. This similarity is remarkable because 80% of the births to non-Hispanic whites occurred within marriages, *four times* the percentage among non-Hispanic blacks.

The effects of mother's age differed the most dramatically across racial and ethnic groups. In contrast, differences in mothers' mean ages were much smaller, with non-Hispanic blacks giving birth at the youngest ages (mean of 24 years), followed by Mexican-origin Hispanics (mean of 26 years), and non-Hispanic whites (mean of 28 years). However, the lower average ages translate into a far higher teenage pregnancy rate among non-Hispanic blacks, which at 28% was roughly twice as high as the rate for Mexican-origin Hispanics (15%) and almost four times higher than the rate for non-Hispanic whites (7%). Mother's age was unrelated to birth weight for non-Hispanic whites. For non-Hispanic blacks, the age effect was negative and statistically significant: a one-year increase in age was associated with a 7-gram decrease in birth weight. Finally, for Mexican-origin Hispanics, age was positive and significant, with a one-year increment in age associated with a 10-gram increase in birth weight. Although these differences were not enough to account for much of the total disparity in birth weight between non-Hispanic blacks and the other two groups, they certainly contributed to it. The deleterious effects of age on maternal and child health for blacks has been characterized as a form of rapid "weathering" that arises from their more difficult life circumstances (Geronimus 1992).

Differences in the effects of mother's education were large across the racial and ethnic groups. Education had a statistically significant relationship with birth weight only for non-Hispanic whites and non-Hispanic blacks; for Mexican-origin Hispanics, education for women had extremely small (and insignificant) effects on birth weight. One additional year of education (beyond the 11th grade) was associated with a 34-gram increase in birth weight for non-Hispanic blacks, an effect that was twice as high as that for non-Hispanic whites of 16 grams. However, the difference in mean years of education between non-Hispanic whites and non-Hispanic blacks was just over one year, substantially smaller than the difference in years of education between Mexican-origin Hispanics and non-Hispanic whites of 3.4 years. A possible reason for the substantially larger effect of education for non-Hispanic blacks is that they face a more challenging environment that they have to navigate to achieve a healthy pregnancy and birth because of disadvantage and discrimination, and education provides women with the knowledge and ability to navigate these environments more successfully.

There was no difference in birth weight between native-born and foreign-born Mexican-origin Hispanics after background characteristics were controlled, in contrast to previous studies that were unable to account entirely for higher birth weights among foreign-born Mexican-origin Hispanics (e.g., Landale, Oropesa, and Gorman 1999). However, non-Hispanic black immigrants had substantially higher birth weights than nonimmigrants. This finding is likely to be related to the selectivity of these two groups, compared with their native-born co-ethnics. Less than 2% of the non-Hispanic blacks were foreign born, in contrast to 81% of the Mexican-origin Hispanics. The small immigrant stream of non-Hispanic blacks was likely to have been more select, in terms of both observed and unobserved characteristics, than was the huge stream of Mexican-origin Hispanics. For non-Hispanic whites, foreign-born mothers had slightly lower birth weights.

We turn next to Table 5, which presents the results for models that included intermediate factors. We focus on two sets of findings. First, we discuss changes in the effects of the background variables (comparing these results to those in Table 4). Second, we discuss the effects of the intermediate factors, again highlighting similarities and differences across the three racial/ethnic groups.

As expected, the effects of the background variables were again attenuated in almost every instance once we incorporated intermediate factors into the models. However, essentially no statistically significant effects were rendered insignificant, although some of the effects changed substantially. In particular, by including the intermediate factors, we accounted for a large portion of the effect of education (for non-Hispanic whites and blacks), of mother's nativity (for non-Hispanic blacks), marital status (for all three groups), and age (especially for non-Hispanic blacks). The largest and most consistent changes occurred for marital status. The intermediate factors in our models accounted for roughly two-thirds of the birth-weight advantage experienced by children of married mothers. This finding suggests that married women generally practiced health-related behaviors during their pregnancies that were beneficial for their babies, such as not

**Table 5. Fixed Effects Linear Regression Models of Birth Weight by Racial/Ethnic Group for Chicago, 1990: Background and Intermediate Variables**

| Variable | Non-Hispanic Whites | | Non-Hispanic Blacks | | Mexican-Origin Hispanics | |
|---|---|---|---|---|---|---|
| Infant's Sex | | | | | | |
| Male[a] | — | — | — | — | — | — |
| Female | –128.6*** | (8.0) | –113.1*** | (5.7) | –113.3*** | (9.3) |
| Mother's Education[b] (years) | 9.0*** | (2.6) | 13.9*** | 2.5 | 0.3 | (4.5) |
| Mother's Nativity | | | | | | |
| U.S. born[a] | — | — | — | — | — | — |
| Foreign born | –36.4** | (11.5) | 68.0** | (23.0) | –32.4* | (13.3) |
| Mother's Marital Status | | | | | | |
| Not married[a] | — | — | — | — | — | — |
| Married | 53.9*** | (12.4) | 55.4*** | (8.5) | 27.6** | (10.6) |
| Mother's Age (years) | 0.5 | (0.9) | –1.5* | (0.7) | 7.6*** | (1.0) |
| First Birth | | | | | | |
| No[a] | — | — | — | — | — | — |
| Yes | –116.7*** | (10.0) | –78.5*** | (7.6) | –124.8*** | (12.0) |
| Interpregnancy Interval[c] (spline) | | | | | | |
| 0–11 months | 2.3 | (3.0) | 7.9*** | (1.6) | 8.5** | (2.8) |
| 12–59 months | 0.6 | (0.4) | –0.1 | (0.3) | 0.5 | (0.4) |
| 60 or more months | –0.9** | (0.3) | –0.5** | (0.2) | –1.5*** | (0.4) |
| Interpregnancy Interval Missing[c] | | | | | | |
| No[a] | — | — | — | — | — | — |
| Yes | –31.1 | (30.1) | –56.8** | (20.0) | –29.2 | (28.4) |
| Gestation Length (spline) | | | | | | |
| 18–41 weeks | 163.4*** | (2.7) | 147.4*** | (1.3) | 142.6*** | (3.1) |
| 42–50 weeks | 15.6 | (15.6) | –34.2*** | (9.3) | –24.3 | (16.2) |
| Adequacy of Prenatal-Care Initiation | | | | | | |
| Inadequate | –12.3 | (29.1) | 20.9 | (14.4) | 21.5 | (27.6) |
| Intermediate | –19.1 | (21.4) | 20.0† | (11.2) | 16.8 | (19.9) |
| Adequate | –2.8 | (11.1) | –14.3* | (7.2) | –6.1 | (11.8) |
| Adequate plus[a] | — | — | — | — | — | — |
| Adequacy of Prenatal-Care Visits | | | | | | |
| Inadequate | –31.5 | (28.8) | –31.0* | (14.8) | –47.8† | (28.5) |
| Intermediate | –19.1 | (15.0) | –16.5† | (9.2) | –36.6* | (15.4) |
| Adequate[a] | — | — | — | — | — | — |
| Adequate plus | –14.7 | (13.5) | 5.6 | (9.6) | 8.6 | (16.5) |
| Number of Prenatal-Care Visits (spline) | | | | | | |
| 0–14 visits | 1.8 | (3.2) | 6.8*** | (1.9) | 3.0 | (3.6) |
| 15 or more visits | –0.4 | (2.8) | 2.0 | (1.6) | –1.1 | (3.5) |

*(continued)*

smoking or consuming alcohol. The other notable change is that the effect of mother's age for non-Hispanic blacks was attenuated substantially and is significant only at the .10 level after the intermediate factors were controlled. This finding suggests that older

*(Table 5, continued)*

| Variable | Non-Hispanic Whites | | Non-Hispanic Blacks | | Mexican-Origin Hispanics | |
|---|---|---|---|---|---|---|
| Prenatal-Care Initiation Missing | | | | | | |
| No[a] | — | — | — | — | — | — |
| Yes | –2.5 | (58.6) | 72.5* | (29.9) | 112.7† | (64.8) |
| Prenatal-Care Visits Missing | | | | | | |
| No[a] | — | — | — | — | — | — |
| Yes | 29.7 | (65.2) | –109.6** | (39.3) | –23.3 | (74.5) |
| Medical-Risk Factors | | | | | | |
| None[a] | — | — | — | — | — | — |
| Any | 9.4 | (10.4) | –36.1*** | (7.8) | –13.8 | (14.5) |
| Smoked During Pregnancy | | | | | | |
| No[a] | — | — | — | — | — | — |
| Yes | –148.6*** | (18.7) | –159.0*** | (11.0) | –122.4** | (42.0) |
| Cigarettes per Day[d] | –2.1* | (0.9) | 0.1 | (0.5) | –0.2 | (2.1) |
| Alcohol Use During Pregnancy | | | | | | |
| None[a] | — | — | — | — | — | — |
| Some | –25.8 | (46.8) | –105.1*** | (26.8) | –30.0 | (245.9) |
| Alcoholic Drinks per Week[e] | 1.4 | (12.3) | 4.4 | (3.9) | –66.2 | (71.3) |
| Alcohol Use Missing | | | | | | |
| No[a] | — | — | — | — | — | — |
| Yes | 39.5 | (54.8) | 36.8 | (35.4) | 142.5 | (258.1) |
| Place of Delivery | | | | | | |
| Hospital[a] | — | — | — | — | — | — |
| Other | 54.9 | (42.0) | –109.0*** | (27.9) | –85.4 | (99.2) |
| Birth Attendant | | | | | | |
| Medical person[a] | — | — | — | — | — | — |
| Midwife | –0.2 | (25.5) | 42.3† | (25.2) | 61.9* | (31.2) |
| Other | –56.0* | (23.9) | 5.3 | (12.2) | –16.7 | (19.8) |
| Constant | 3,536.1*** | (84.7) | 3,499.0*** | (46.7) | 3,713.5*** | (82.6) |
| Model *F* test (*df*) | 242.0*** | (31) | 738.0*** | (31) | 133.3*** | (31) |
| Tract Fixed Effects | Yes | | Yes | | Yes | |
| Tract Fixed Effects *F* test (*df*) | 1.00 | (602) | 1.15** | (628) | 1.11* | (492) |
| Adjusted $R^2$ | 0.39 | | 0.48 | | 0.30 | |
| Number of Observations | 12,918 | | 26,005 | | 10,181 | |

*Source:* Authors' calculations using 1990 data on Chicago vital statistics.

*Note:* Standard errors are shown in parentheses.

[a]Reference category.

[b]Years of schooling beyond the 11th grade.

[c]Among women with a prior live birth.

[d]Cigarettes per day among women who smoked during pregnancy.

[e]Alcoholic drinks per week among women who used alcohol during pregnancy.

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

non-Hispanic black mothers had less favorable pregnancy-related behaviors than did younger mothers; once these behaviors were taken into account, mother's age had a minor effect on birth weight (as was the case for non-Hispanic whites).

The effects of intermediate variables that were similar across the three racial and ethnic groups included first birth, interpregnancy interval, gestation length, and smoking. Substantial differences were observed for medical-risk factors, alcohol use, and place of delivery. A number of the intermediate variables did not have significant effects. For example, few of the indicators of prenatal care were statistically significant.

For the three intermediate variables for which there were substantial differences in effects across the groups, the only statistically significant effects were for non-Hispanic blacks. For this group, the deleterious effects of having a medical-risk factor, using alcohol during pregnancy, or having a nonhospital delivery were large, even though in all three cases there were minor differences in levels compared with non-Hispanic whites. This finding suggests a source of disadvantage for non-Hispanic blacks that may reflect either more serious medical-risk factors, more damaging patterns of alcohol use, poorer assistance with delivery, or worse treatment for medical-risk factors. The absence of clear effects for prenatal care may have been caused by adverse selection (i.e., women who anticipated problems with their pregnancies may have initiated earlier prenatal care) or other factors. However, there is some evidence that the adequacy of prenatal care visits was associated with higher birth weight.

## Decomposing Race/Ethnic Differentials in Birth Weight

The final task is to summarize the differences in birth weight across the three racial and ethnic groups and, in particular, to identify the extent to which the measured background and intermediate covariates accounted for observed differences. In Table 6, we present a decomposition of the birth-weight differences among the three groups. The entries along the diagonal show observed values. The off-diagonal elements describe the counterfactual associated with a model (identified by the column) and a set of characteristics (identified by the row). For example, the top-right entry in the table shows the predicted mean birth weight for non-Hispanic whites if the effects of their (background and intermediate) characteristics on birth weight were the same as those for Mexican-origin Hispanics. The difference between this value (3,417.4) and the actual value for non-Hispanic whites (3,418.5) reflects overall differences in relationships, which are minor. The difference compared with the actual value for Mexican-origin Hispanics (3,383.8) reflects differences in characteristics, which, in this case, accounts for essentially the entire difference in mean birth weight between these two groups. Thus, the results indicate that the background and intermediate factors in the models account for all the birth-weight difference between non-Hispanic whites and Mexican-origin Hispanics. The result is symmetric, in that we reached the same conclusion when we examined predicted mean birth weight for Mexican-origin Hispanics using estimated relationships for non-Hispanic whites.

The measured characteristics account for just over half the birth-weight gap between non-Hispanic blacks and whites. Of the 331.7-gram difference in birth weight between non-Hispanic blacks and whites, 51% is accounted for by measured characteristics that were based on the model for non-Hispanic whites, and 55% is accounted for by measured characteristics that were based on the model for non-Hispanic blacks. That leaves 44%–49% that is accounted for by differences in the ways that the measured characteristics affect birth weight, as well as the omitted variables.

Comparing non-Hispanic blacks and Mexican-origin Hispanics, we found that the results differ, depending on which model is selected as the standard (note, however, that the standard errors of the counterfactual estimates are large). Of the 297.0-gram difference in birth weight between these two groups, 66% is accounted for by differences in characteristics when the non-Hispanic black model is used, while 44% is accounted for

**Table 6. Decomposition of Racial/Ethnic Differences in Birth Weight for Chicago, 1990**

| Racial/Ethnic Group | Model: Non-Hispanic Whites | | Model: Non-Hispanic Blacks | | Model: Mexican-origin Hispanics | |
|---|---|---|---|---|---|---|
| Non-Hispanic Whites | 3,418.5[a] | (3.9) | 3,269.4 | (7.0) | 3,417.4 | (13.0) |
| Non-Hispanic Blacks | 3,249.3 | (8.8) | 3,086.8[a] | (2.8) | 3,253.9 | (12.3) |
| Mexican-Origin Hispanics | 3,385.6 | (9.4) | 3,292.4 | (18.9) | 3,383.8[a] | (4.5) |

*Source:* Authors' calculations using 1990 data on Chicago vital statistics.

*Notes:* Standard errors are shown in parentheses. Estimates are based on regression models shown in Table 5.

[a]Actual observed value.

when the Mexican-origin Hispanic model is used. The higher percentage explained by the non-Hispanic black model is due to this model's substantially better fit. In particular, the non-Hispanic black model has an adjusted $R^2$ of .48—indicating that this model explained roughly half the variation in birth weight for non-Hispanic blacks. In contrast, the model for Mexican-origin Hispanics has an adjusted $R^2$ of .30. The implication, however, is that there is a fairly large confidence interval in attributing this racial/ethnic gap in birth weight between characteristics and relationships. Nevertheless, it is clear that differences in characteristics do not explain the entire difference between non-Hispanic blacks and Mexican-origin Hispanics.

Overall these results suggest that the disadvantage in birth weights for infants who are born to non-Hispanic black mothers—compared with non-Hispanic white and Mexican-origin Hispanic mothers—was not simply the result of non-Hispanic blacks being more disadvantaged according to their (measured) social characteristics and reproductive behaviors. Rather, there were significant differences in birth outcomes between non-Hispanic blacks and the other two groups when the characteristics of the mother and the pregnancy were set at exactly the same values, with non-Hispanic blacks faring substantially worse. This may be the result of the omission of important covariates—such as household income or measures of maternal stress or health status. However, it also suggests that for non-Hispanic blacks, not only were the effects of demographic, social, and reproductive factors overall less beneficial for the positive factors and more deleterious for the negative factors (as we showed earlier), but the consequences for birth weight of these differences were large.

## CONCLUSIONS

The goal of this study was to examine differences in birth weight across racial and ethnic groups in Chicago in 1990. Specifically, our analyses addressed three questions. First, what proportion of racial and ethnic birth-weight disparities is explained by differences in maternal characteristics and health and reproductive behaviors? Second, what proportion of these disparities is explained by differences in the *effects* of these characteristics or behaviors on birth weight? Third, what proportion of the racial and ethnic disparities in birth weight are accounted for by neighborhood factors?

We found that measured characteristics accounted for about half the birth-weight gap between non-Hispanic whites and blacks (of 332 grams) and between non-Hispanic blacks and Mexican-origin Hispanics (of 297 grams). In both cases, the remainder was accounted for by differences in the effects of variables or unmeasured variables. This result has important implications for policies and programs to improve birth weight and to eliminate racial and ethnic disparities in infants' health. In particular, it suggests that it is not enough simply to provide non-Hispanic black women with more advantageous characteristics, such as better education and access to medical care. Our results indicate that doing so may eliminate roughly half the current disparity in birth weight, at best. A slightly larger portion may be explained by differences in characteristics if certain unmeasured factors were included in the analysis. To eliminate the disparity, however, more significant structural changes are required—changes that would alter the way in which mothers' characteristics and behaviors affect birth outcomes.

The principal differences in characteristics that led to low birth weight among non-Hispanic black mothers were their lower levels of education, higher rates of nonmarital births, less-adequate prenatal care, higher rates of smoking, and, especially, shorter gestation lengths. A number of factors had distinct effects for non-Hispanic blacks compared with the other two groups, including mother's age, education, medical-risk factors, and alcohol use. Policy interventions to improve birth weight among non-Hispanic blacks need to focus on both sets of factors to eliminate racial and ethnic disparities. Policies that are designed to alter mothers' characteristics are fairly easy to design and implement, but ones that are aimed at changing relationships are more difficult to conceptualize, let alone implement.

One reason why relationships may differ—for example, that the effects of medical-risk factors have a strong negative effect on birth weight only for non-Hispanic blacks—is that the underlying factor is actually different across the racial/ethnic groups. For example, given the same risk factor, non-Hispanic blacks may suffer from worse forms of a disease or condition. From an analytic perspective, better measurement of these factors may be the solution to this problem. However, another reason why relationships may vary is that processes may differ fundamentally across the racial/ethnic groups. For instance, non-Hispanic blacks may, for a variety of reasons, receive poorer health care for their risk factors, although the actual type and severity of the disease or condition is no different from that for either of the other two groups. Both issues should be investigated to develop a better understanding of racial and ethnic differences in birth weight and to design policies to eliminate them.

The Mexican-origin Hispanics in Chicago had remarkably good birth outcomes, despite their apparent socioeconomic disadvantage. Among the specific factors that contributed to such favorable birth outcomes were their lower levels of smoking and alcohol use and their lack of medical-risk factors. In addition, the Mexican-origin Hispanics had gestation lengths similar to those of the non-Hispanic whites. Our results suggest that although their mean birth weight was slightly lower than that for non-Hispanic whites, differences in the levels of measured covariates accounted for all this difference. A number of clear changes may be pursued from a policy perspective to improve birth weight among Mexican-origin Hispanics. They include increasing mothers' ages at birth and reducing nonmarital births.

Our results suggest that neighborhood factors are important in explaining differences in mean birth weight, accounting for 14% of the raw difference between non-Hispanic blacks and Mexican-origin Hispanics and as much as 30% of the difference between non-Hispanic blacks and whites. This is a particularly noteworthy result, given the persistent and striking spatial variation in the social, economic, and health characteristics of urban populations. In ongoing research, we are investigating the specific neighborhood factors that account for this finding.

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